

Title: Acid Mist Formation in RFO-Fired Boilers and Plume Opacity Control

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Summary: Because of chemical reactions that take place between the oxides of vanadium, oxygen and SO₂, the flue gas from residual fuel oil (RFO)-fired boilers typically contains higher concentrations of SO₃ than those found in coal-fired units. Although SO₃ formation cannot be prevented, an understanding of the factors that govern the conversion of SO₂ have led to the development of operational procedures to minimize SO₃. Using visual aids, the effects of time, temperature, and flue gas SO₂ and O₂ concentrations are discussed.

At the air heater inlet the flue gas SO₃ is present in combined form as sulphate particles and as acid gas, H₂SO_{4(g)}. Localized quenching caused by air heater inleakage causes at least a portion of the acid gas to condense, forming an acid mist even when average outlet temperatures are above the acid dew point. As demonstrated by the procedures established to measure SO₃, sulphuric acid mist is extremely stable, requiring that the flue gas be reheated to at least 280° C to achieve evaporation. A surprisingly small amount of SO₃ on a volumetric basis contributes considerably to the mass emission rate. For example, 5 ppm acid gas is equivalent to about 0.02 lbs/10⁶ Btu of aqueous sulphuric acid.

Acid mist in the flue gas compromises mass emission measurements, whether using EPA Method 5 or 17. Both Methods were developed for compliance testing and the effect of acid mist was not carefully considered. Method 17 collects both the particulate and acid mist. The amount of acid gas that passes through the thimble filter depends of the mist condensation rate in the air heater. During Method 5 testing, the sampled flue gas is cooled such that all but about 1 ppm SO₃ is collected on the filter. Sulphate may account for 60% or more of the particulate, an amount well in excess of that which can be neutralized by available metals, e.g., V, Ni, Fe, Na, Mg. Utilities planning on reporting TRI SO₃ as a percentage of SO₂ emission will greatly overstate the contribution, as most of the SO₃ is already reported as part of the particulate emission. An argument is presented for a new particulate testing methodology that would exclude acid mist collection.

Flue gas acid mist may also account for the formation of a stable, attached, bluish-white stack plume. Although measured opacity may be within permitted regulatory limits, the existence of an acid plume often creates a public perception of environmental noncompliance. This perception may represent the greatest operational challenge to RFO-firing. The normal tendency of boiler operators is to increase excess air in an effort to reduce plume opacity. Unfortunately, this strategy may be unacceptable as increasing excess air also increases SO₃ and NO_x.

To reduce plume opacity it is necessary to either chemically neutralize SO_3 , and/or limit SO_3 formation. Flue gas treatment to neutralize SO_3 from RFO-fired boilers has been successfully achieved in Japan, using ammonia, and in England, using magnesium hydroxide powder. In both cases, however, success was achieved at the expense of increasing particulate emissions.

Fuel additives, especially magnesium hydroxide suspensions, have also been successfully used to minimize opacity. The reduction is achieved through the formation of large sulphate particles, e.g., 2-10 microns, that significantly reduce visible light scattering. Care must be exercised in applying fuel additives to avoid excess boiler tube fouling and high particulate emission.